Assessment of quadriceps muscle mass with ultrasound in critically ill patients: intra- and inter-observer agreement and sensitivity

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Loss of muscle mass and muscle weakness are common in critically ill patients[1;2] and have important clinical implications[3]. Most of the muscle atrophy takes place in the first 2 weeks of ICU stay[1;2]. Evaluation of the prevention of muscle atrophy implies reliable tools for assessment. Since critically ill patients are often sedated, voluntary muscle strength tests cannot be performed due to an impaired cooperation[4]. Measuring of the quadriceps mass by ultrasound has gained interest, because of its non-invasive nature and bedside application[1]. In addition, this measurement correlates well with CT scan assessment, without radiation and a technically difficult procedure for critically ill patients, and the results are immediately available[5]. We studied the intra-observer as well as the inter-observer agreement of ultrasound measurement in the assessment of the quadriceps muscle mass in critically ill patients. In addition, we investigated the sensitivity to detect muscle loss over 1 week with repeated ultrasound measurements at day 3 or 4 and day 10 or 11.

Ultrasound measurements (Vivid 7, GE Healthcare, Herentals, Belgium) of muscle thickness were performed on the medical and surgical ICU of the University Hospitals, Leuven, Belgium. Patients were eligible for inclusion irrespective of reason for admission. Patients with different length of ICU stay were selected at random. Some patients were on the ICU for only a few days, while others were already in the ICU for several days or even weeks. The ultrasound images were used to investigate the thickness of the right rectus femoris and vastus intermedius together. The methodology was similar to Seymour et al[5] (see details in online supplement S1). Data collection and statistical analysis are explained in online supplement S2. All patients were included in an ongoing randomized controlled trial examining the effect of neuromuscular electrical stimulation in critically ill patients. (ClinicalTrials.gov: NCT02133300)

For all 3 parts of this study, measurements of the quadriceps muscle layer thickness were performed in 25 patients. Patient characteristics are shown in online supplement table S1. Intra-observer agreement showed an ICC of 0.995 (95% CI: 0.989 – 0.998). For the inter-observer agreement, the ICC was 0.951 (95%CI: 0.890 - 0.979). The differences between the two measurements of the intra-observer agreement were not statistically significant and below 0.2cm (1.66 vs 1.67cm; p= 0.528). For the inter-observer agreement, the differences between the two observers were statistically significant (1.88 vs 1.63cm; p= 0.002). Analysis of muscle thickness showed a significant decrease of 11% from 2.18± 0.83cm to 1.95± 0.76cm (p= 0.012). The individual measurements of all patients are shown in online supplement figure S3. The Bland and Altman plots of the intra- and inter-observer agreement are added in figure 1.

Our results show that muscle thickness as measured by the ultrasound, can be reliably assessed within observers, but not between observers. In addition, the method is sensitive to detect muscle wasting in critically ill patients provided that the same investigator performs the repeated measurements. Furthermore, this method is unrelated to patient cooperation and can easily be performed bedside in all critically ill patients.

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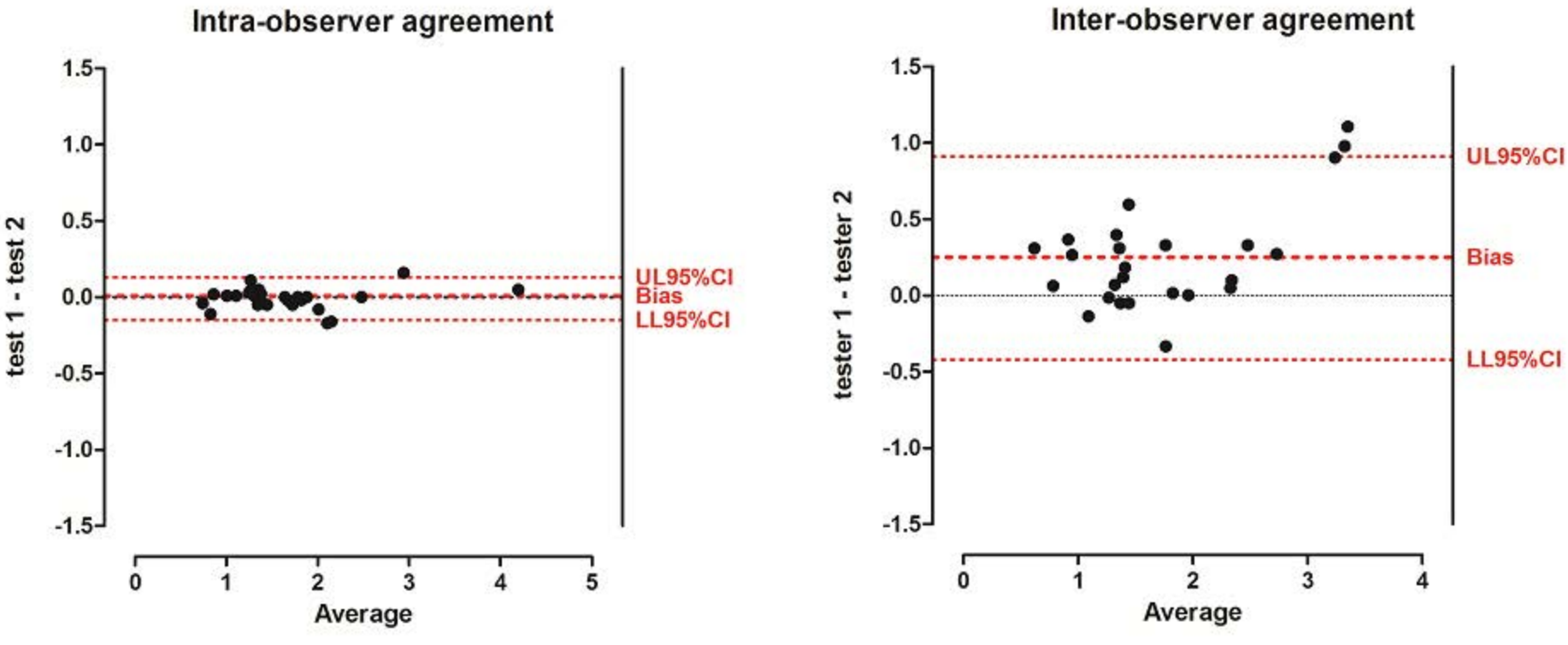
Figure 1: Bland and Altman plot of the intra- and inter-observer agreement results



UL95%CI: upper limit 95% confidence interval; LL95%CI: lower limit 95% confidence interval